

Fig. 1

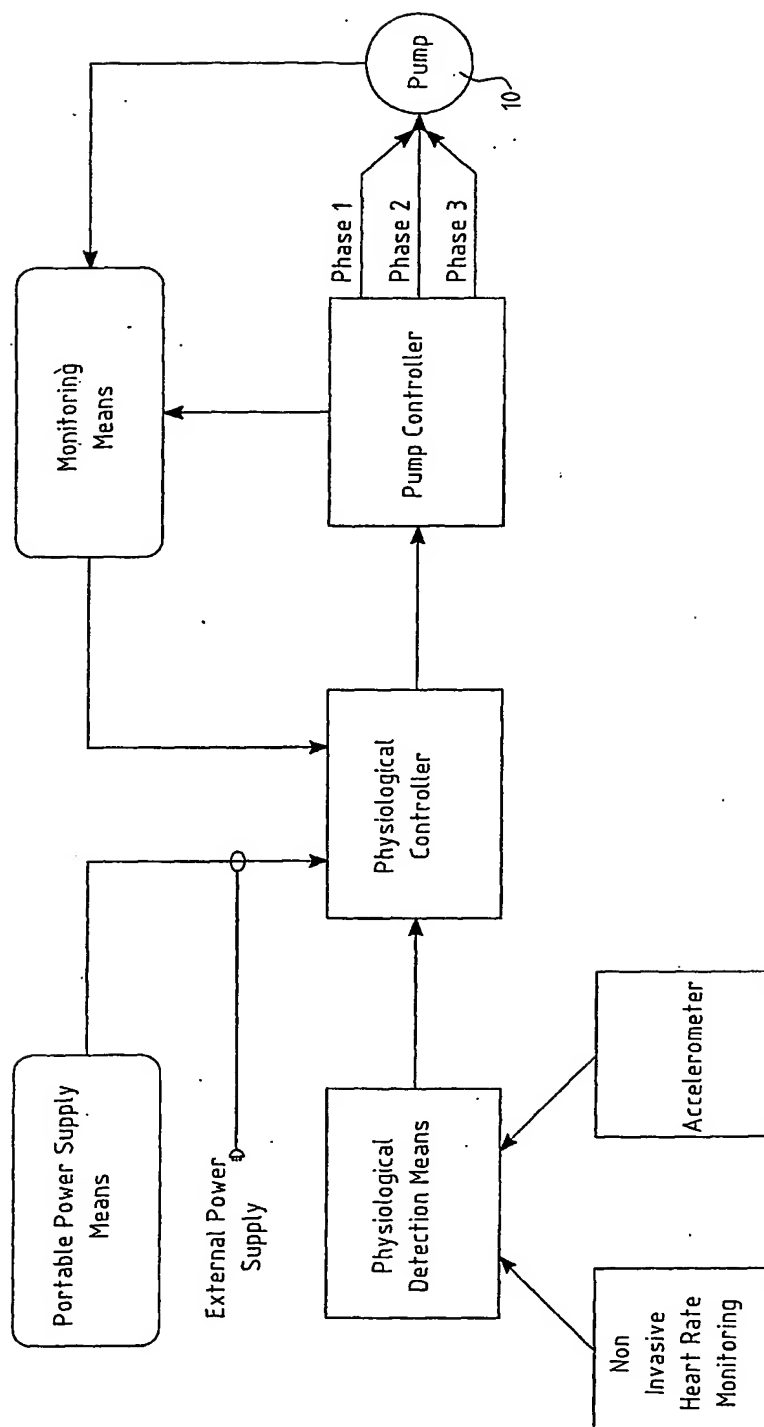


Fig. 2

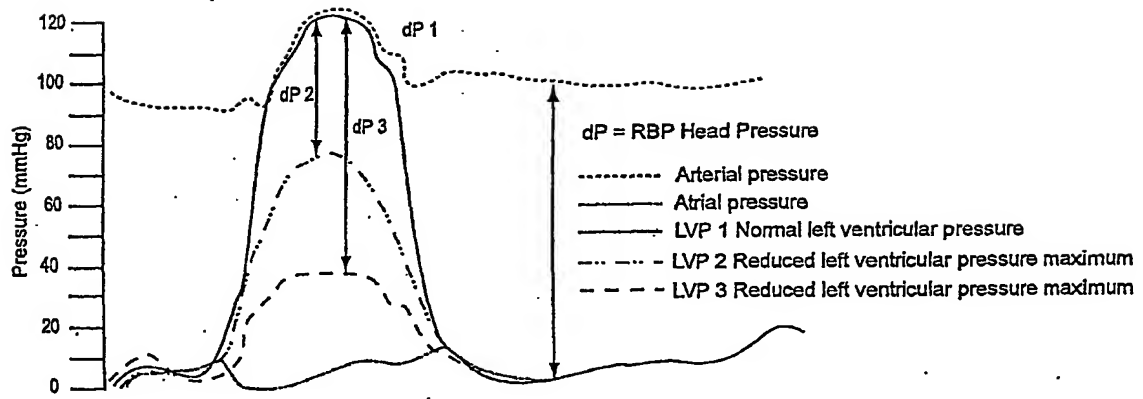


Fig. 3

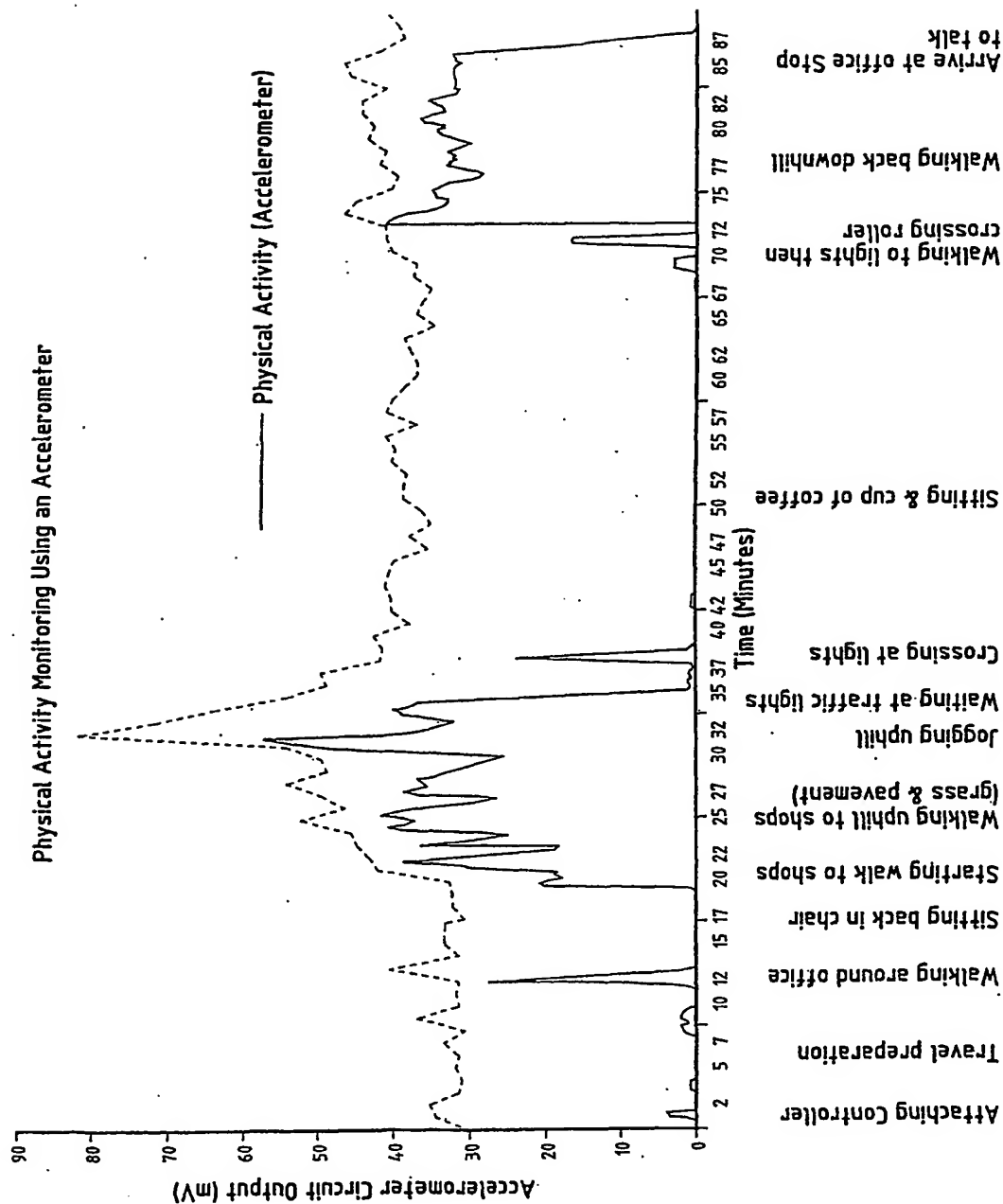


Fig. 4

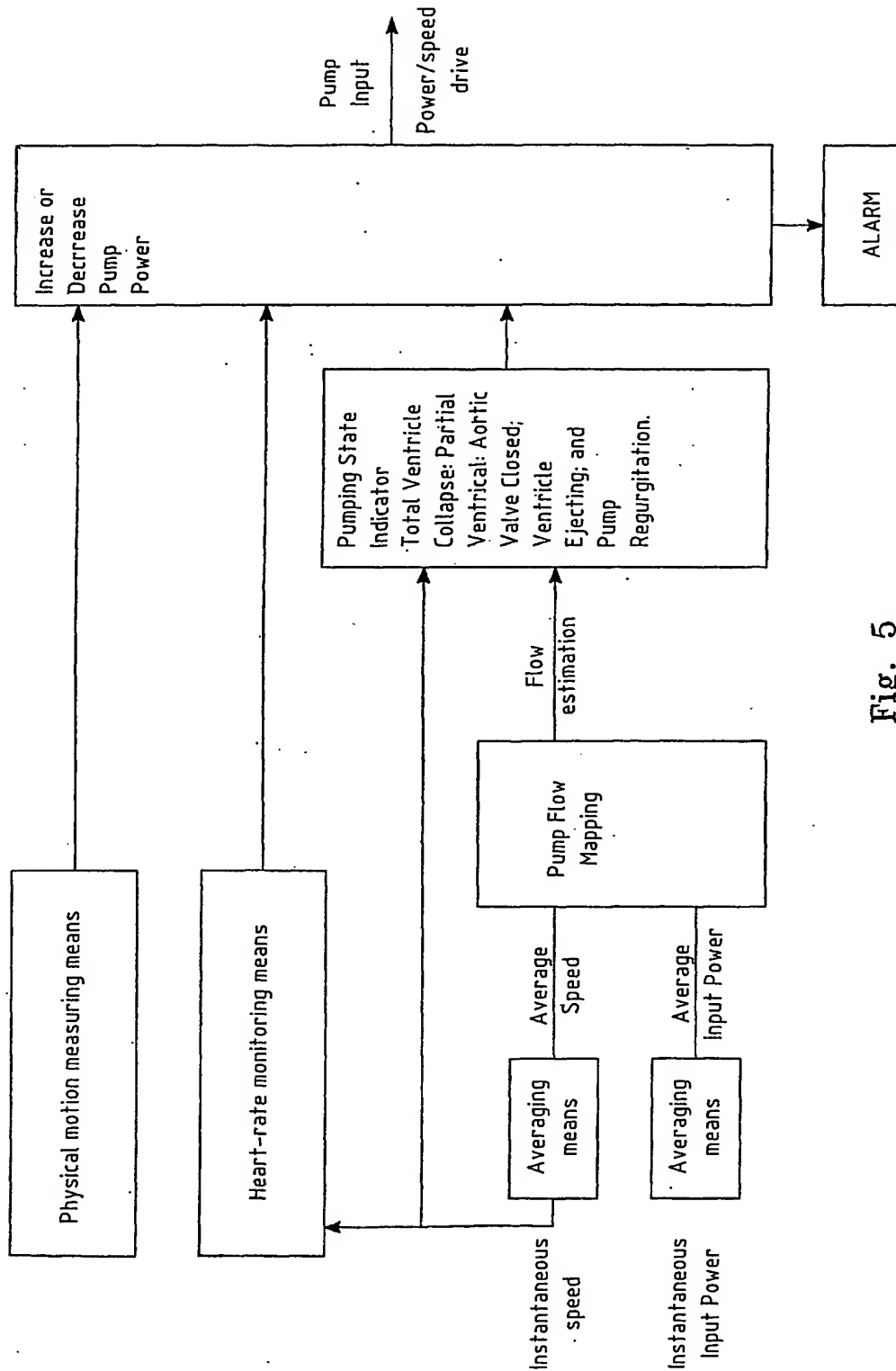
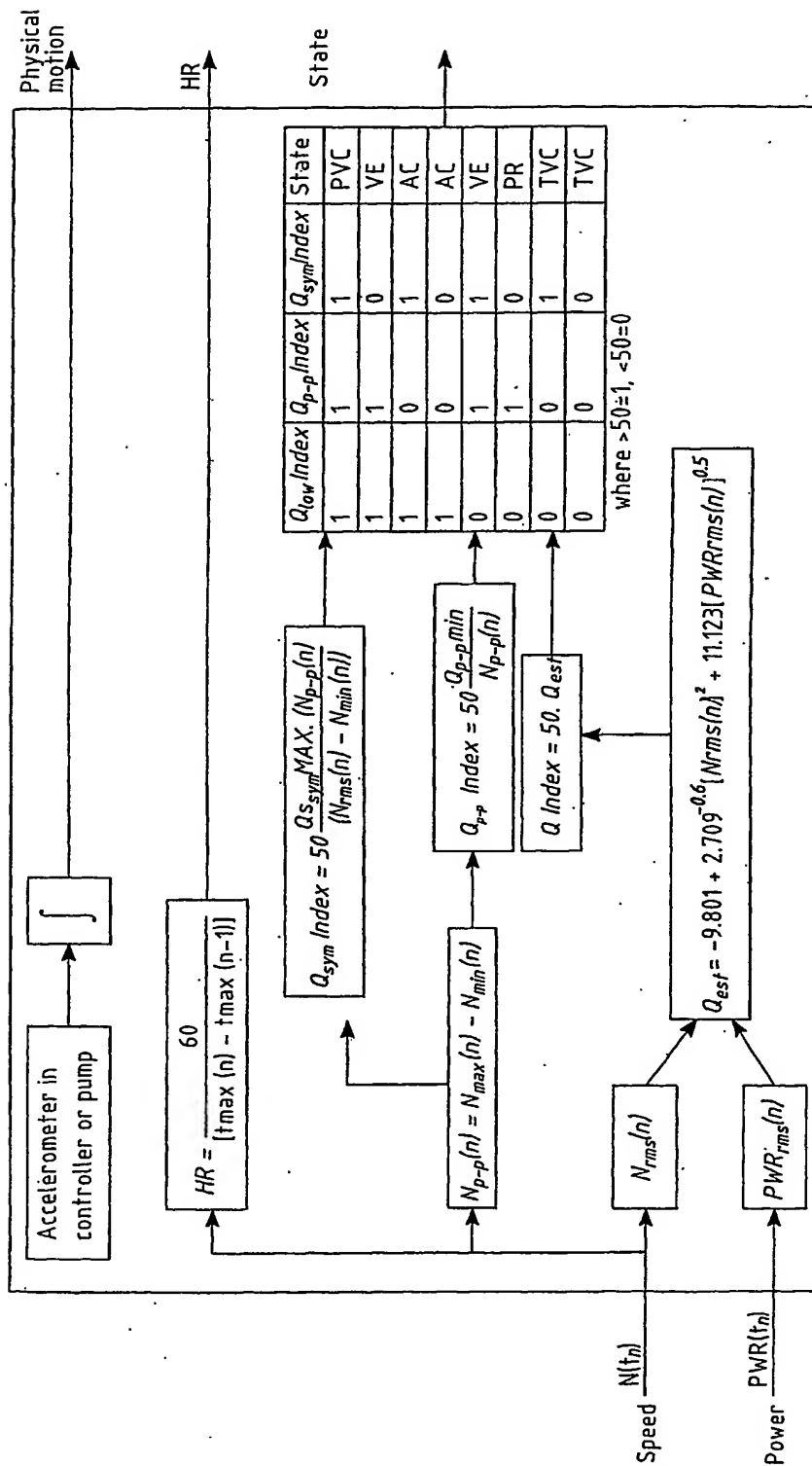
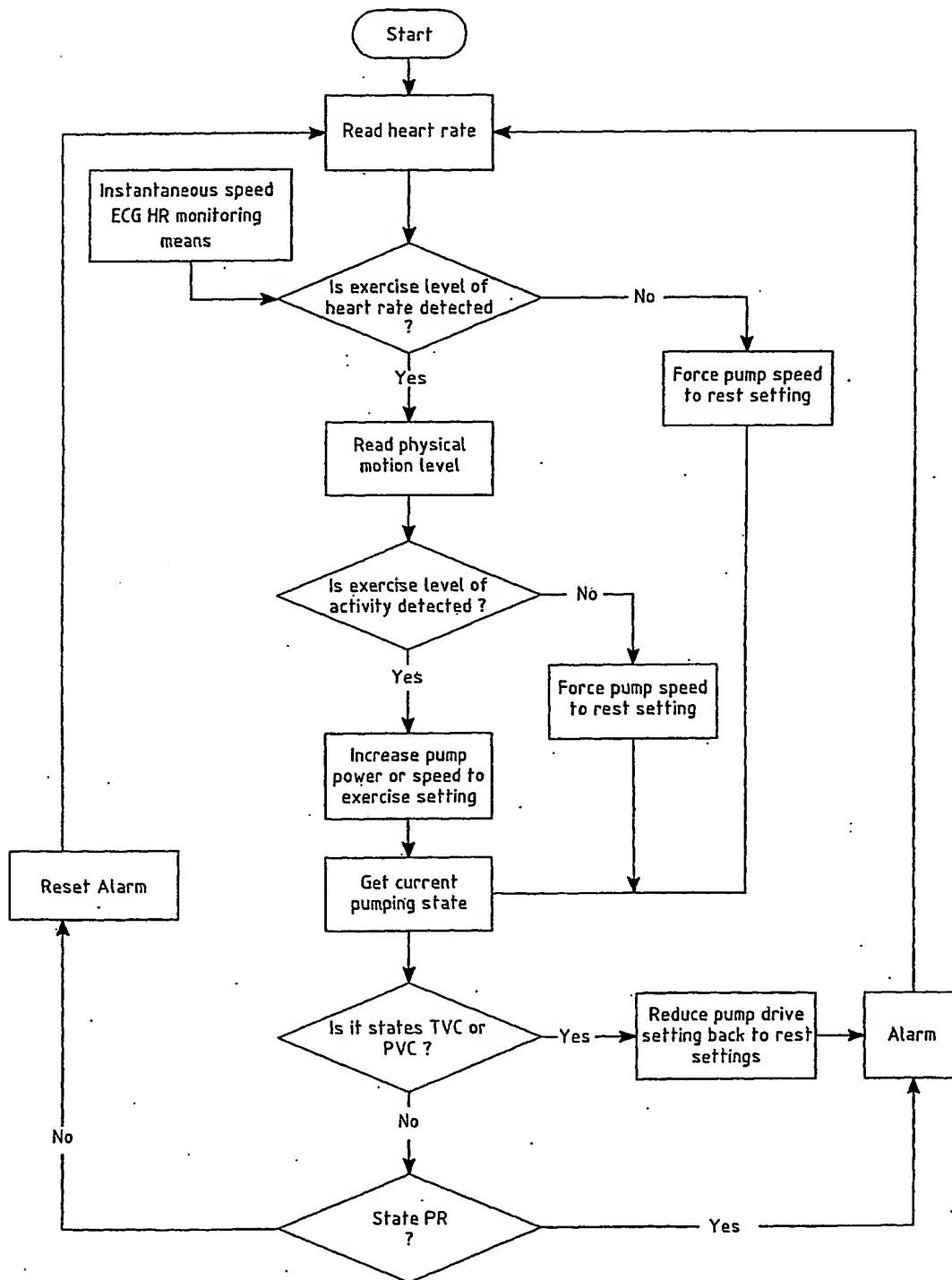


Fig. 5



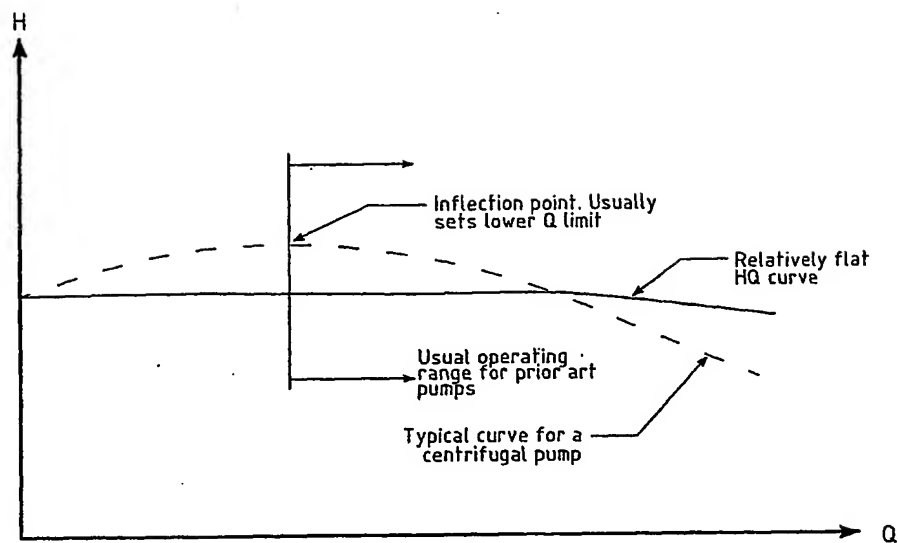
A block diagram of the Pumping state detection module. From instantaneous pump speed and power ( $N(t)$ ,  $PWR(t)$ ), rms speed and RMS power ( $N_{rms}(n)$ ,  $PWR_{rms}(n)$ ) were derived. From the RMS parameters, pump flow,  $Q_{est}(t)$  was derived. Pumping state indexes for PVC, PVC AC, VE, PR were generated from the RMS and instantaneous speed parameters given flow rate boundaries. Heart rate derived from  $N(t)$  and physical motion integrating the output of an accelerometer mounted in the controller or pump.

Fig. 6



Flow chart for determining pump drive set point change through the integration of the 3 methods of non-invasive detection (physical motion, HR and state detection) for exercise rate response control.

Fig. 7



HQ curves for the pump and a typical centrifugal pump which exhibits a peak in the HQ curve.

Fig. 8



## Physiological Demand Responsive Control System

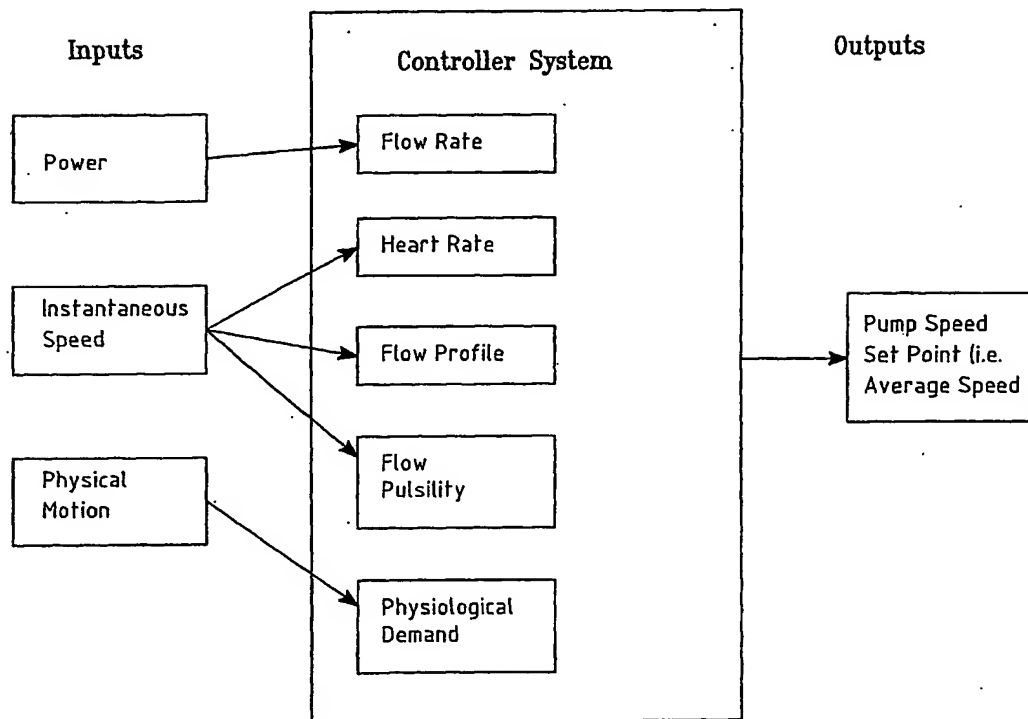


Fig. 9